United States Department of Agriculture
Natural Resources Conservation Service

CEAP Conservation Insight

November 2006

Ephemeral Gully Erosion in Cheney Lake Watershed, Kansas

Summary Findings

- About 10 percent of the watershed contributes 76 percent of the sediment load to Cheney Reservoir.
- Computer models can predict areas of the watershed that have the highest potential for sediment loading.
- Treating all ephemeral gullies in the Cheney Lake watershed potentially can reduce the sediment load to the reservoir by 35 percent.
- In this watershed, and in other watersheds with similar conditions, focused voluntary implementation of management practices that reduce soil loss in the areas with the highest potential for sediment loading will improve water quality more rapidly and at less cost than random implementation of practices across the watershed.

Background

Cheney Lake Watershed (Fig. 1) covers 633,000 acres within five counties in south-central Kansas. Over 99 percent of the watershed is used for agriculture, including small dairies, diversified crop and livestock farms, rangeland, and large acreages under center-pivot irrigation.

The watershed drains into the North Fork Ninnescah River, which flows into Cheney Reservoir. The reservoir was built in the early 1960s as a 100-year multi-purpose project for water supply, wildlife area, and flood control. It has a surface area of approximately 15 square miles with an average depth of 16 feet and contains 168,000 acre-feet of water. The City of Wichita draws 70 percent of its daily water supply from the reservoir.

The two primary resource concerns for the Cheney Lake Watershed are sediment and phosphorus pollution. Sediment is a concern with regard to water quality and to reservoir storage capacity. Phosphorus became a concern during the early 1990's, when Cheney Reservoir experienced algae blooms significant enough to produce taste and odor problems in Wichita's water. The reservoir currently is designated a high-priority impaired water body under the Clean Water Act, with impairments listed for eutrophication and siltation.

A farmer-led Citizen's Management Committee created by the Reno County Conservation District has implemented a master plan for watershed pollution management to reduce phosphorus and sediment loading by 40 to 45 percent and double the life of the reservoir. The committee's goal is to implement management practices on the land with little or no cost to the landowner or operator.

A five-year comprehensive water monitoring study also was implemented in the watershed, in 1996, through a partnership with the City of Wichita, the U.S. Geological Survey (USGS), and the U.S. Bureau of Reclamation. A two-year macroinvertebrate study complements the USGS water quality study.

As a Special Emphasis Watershed for the Conservation Effects Assessment Project (CEAP) the Cheney Lake watershed has been investigated by the Natural Resources Conservation Service (NRCS) using the Annualized Agricultural Non-Point Source (AnnAGNPS) computer modeling system. All AnnAGNPS modeling within this project has been validated and calibrated to the USGS data collected from 1996 to 2000.

This *CEAP Conservation Insight* presents significant findings regarding the impact of ephemeral gullies. The NRCS investigation also assesses the effects of the Conservation Reserve Program, tillage practices, irrigation scheduling practices, concentrated animal feeding operations, atrazine management practices,

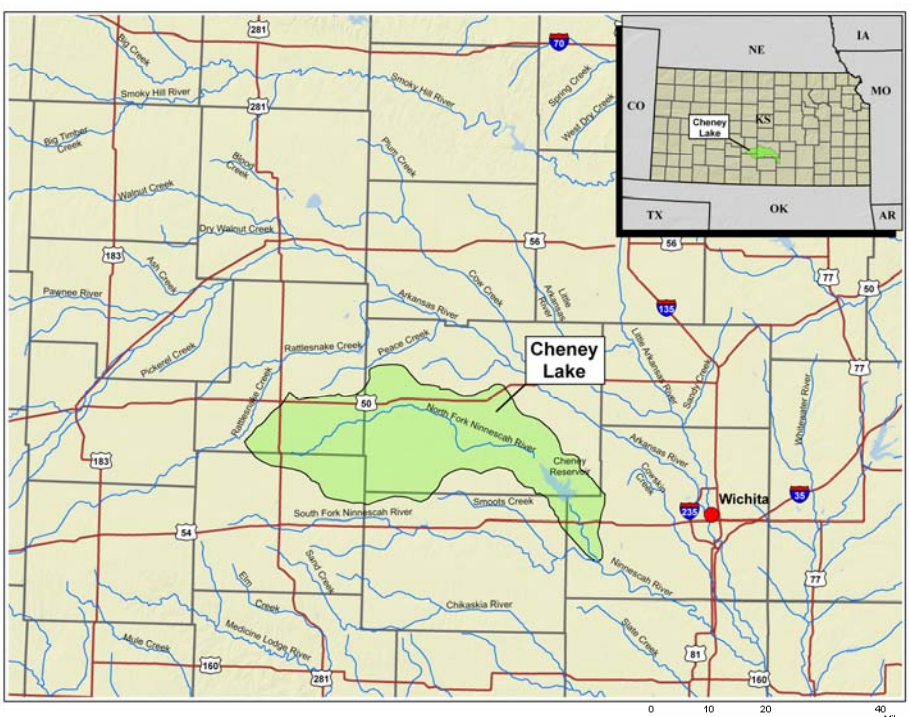

Figure 1. — Location of the Cheney Lake Watershed in Kansas

and the contribution of sediment from ephemeral gullies.

Potential Sources of Sediment

Sources of sediment within this agricultural watershed include sheet and rill erosion, ephemeral gully erosion, and stream bank erosion. Sheet and rill erosion is defined as the removal of layers of soil from the land surface by the action of rainfall and runoff. Sheet and rill erosion can be erased by tillage practices, and the next erosive action may occur in a different location. Typically, sheet and rill erosion creates shallow, parallel channels that are uniformly spaced and sized. Estimates of soil loss from sheet and rill erosion typically are calculated using the Universal Soil Loss Equation (USLE). Examples of management practices to address sheet and rill erosion include conservation tillage, gradient terraces, and field buffers.

Ephemeral gully erosion, which results from concentrated water flow, produces narrow, incised channels that cut down to a less erodible layer. These temporary gullies may be obscured by tillage (Figs. 2, 3), but they will reform in the same location at the next rainfall event. As soil is moved into the voided area by tillage, an area wider than the actual gully is damaged. Erosion loss from ephemeral gullies -- beyond the calculated sheet and rill erosion loss -- is not estimated by the USLE model and thus is not included in national and regional assessments of erosion control progress. Examples of management practices that will address ephemeral gully erosion include grassed waterways or shaping and seeding the affected area with permanent vegetation.

Stream bank erosion pertains to the loss of soil from the incised banks of a perennial stream system. Stream bank losses are best determined by a physical assessment of the stream system. Treatment for stream bank erosion includes some form of bank stabilization.

Investigation of Sediment Origin

As watershed residents attempt to reduce suspended solids within the Cheney Lake watershed stream system, it is necessary first to determine the primary sources of sediment. Early modeling efforts in the watershed assumed two primary sources—stream bank loss and sheet and rill erosion. Estimates of stream bank erosion were based upon a 1996 investigation by the Kansas NRCS state geologist. A survey of the North Fork Ninnescah stream system at that time determined that less than 15 percent of the sediment load originated from the stream banks.

Figure 2. — Ephemeral gully in a crop field in the Cheney Lake Watershed, August 26, 2005

Figure 3. **—** The same field on October 17, 2005, with ephemeral gully obscured by tillage and planting operations

When the AnnAGNPS model results of the Cheney Lake watershed were validated with USGS stream monitoring data, there appeared to be a gap between the sediment load predicted by the model and the actual sediment load measured by USGS. Other outputs predicted by the model were in agreement with the USGS data. Figure 4 shows the difference in tons of sediment measured by USGS and the sediment predicted by the model.

Upon investigation it was determined that the USLE model did not capture erosion as a result of ephemeral gullies within crop fields. The hypothesis was that ephemeral gullies would prove to be the source of the sediments that were not accounted for within the early modeling studies. The AnnAGNPS model was enhanced by adding a method to account for ephemeral gully erosion. As a result, current modeling results now closely match the actual measured in-stream sediment load.

With this modeling enhancement the CEAP investigation has been able to rank land area within the watershed according to its predicted sediment contribution to the overall loading of the North Fork Ninnescah River. Using this ranking, it is possible to see the relation-

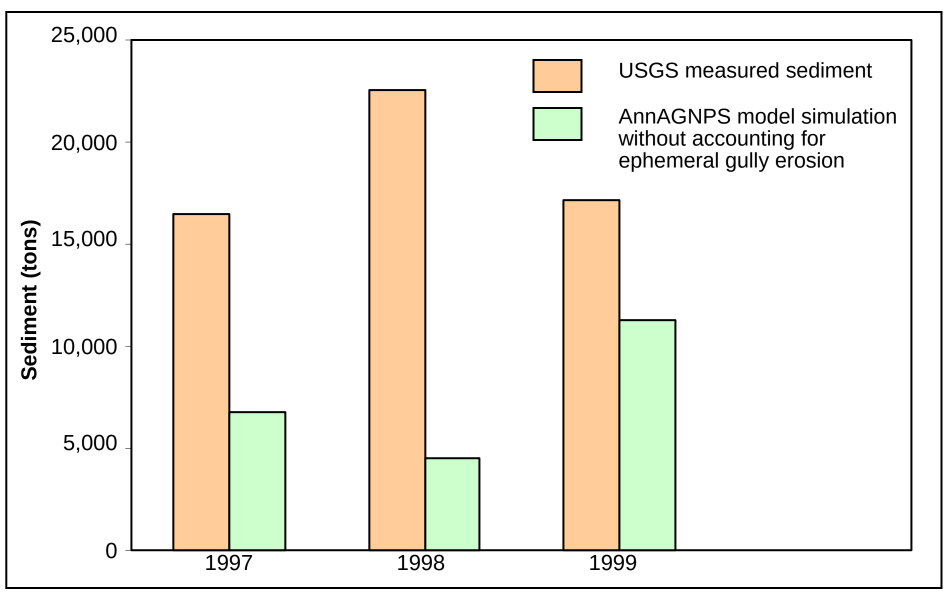

Figure 4. — Comparison plots of observed and predicted sediment yield at the USGS gauging station (07144870) on the North Fork Ninnescah River above Cheney Reservoir, 1997-1999

ship between the percentage of sediment load and the percentage of contributing cells. The graph in Figure 5 illustrates this relationship showing that roughly 10 percent of the 200-acre cells in the watershed are contributing approximately 76 percent of the sediment load. The graph further illustrates the difference between the sediment load when ephemeral gullies are included or excluded from the equation. This graph indicates that approximately 35 percent of the sediment load in this watershed could be eliminated by treating the ephemeral gullies.

The relationship between sediment and contributing cells can also be illustrated spatially with the watershed map shown in Figure 6. The purple-shaded areas, based on AnnAGNPS model estimates, make up the 10 percent of the watershed that contributes 76 percent of the sediment. The green-shaded areas are those areas that are contributing less than the highest percent but higher than the mean contribution.

Figure 7 shows the 989 points where ephemeral gully erosion can originate,

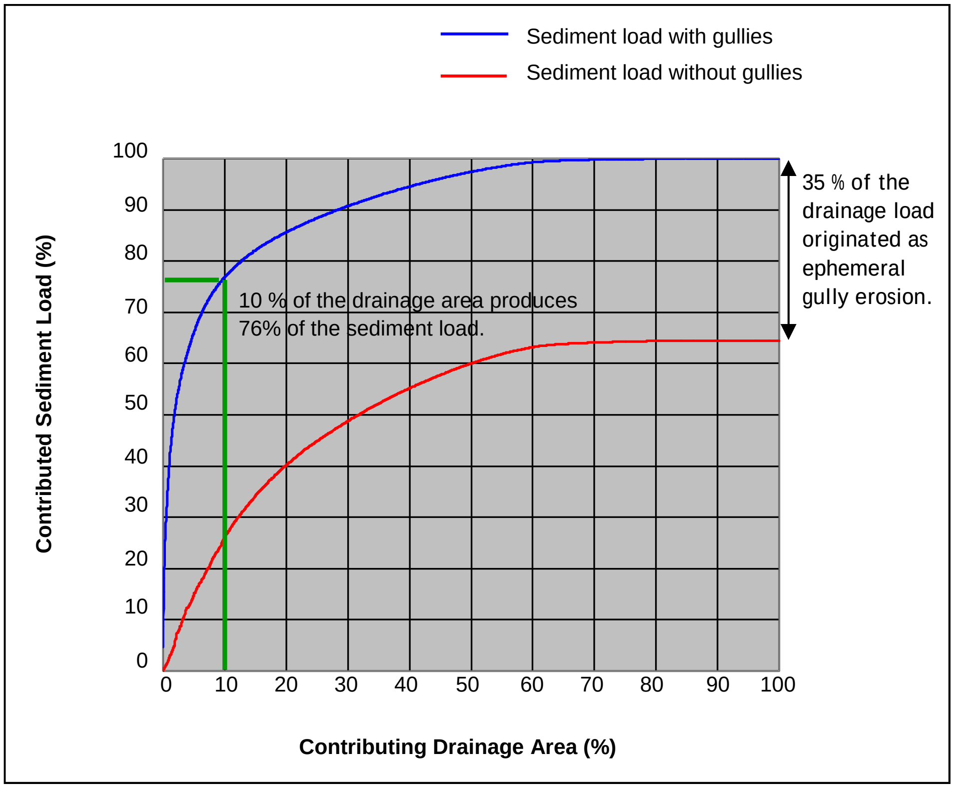

Figure 5. — Cheney Reservoir watershed sediment load, by unit area ranking ratio

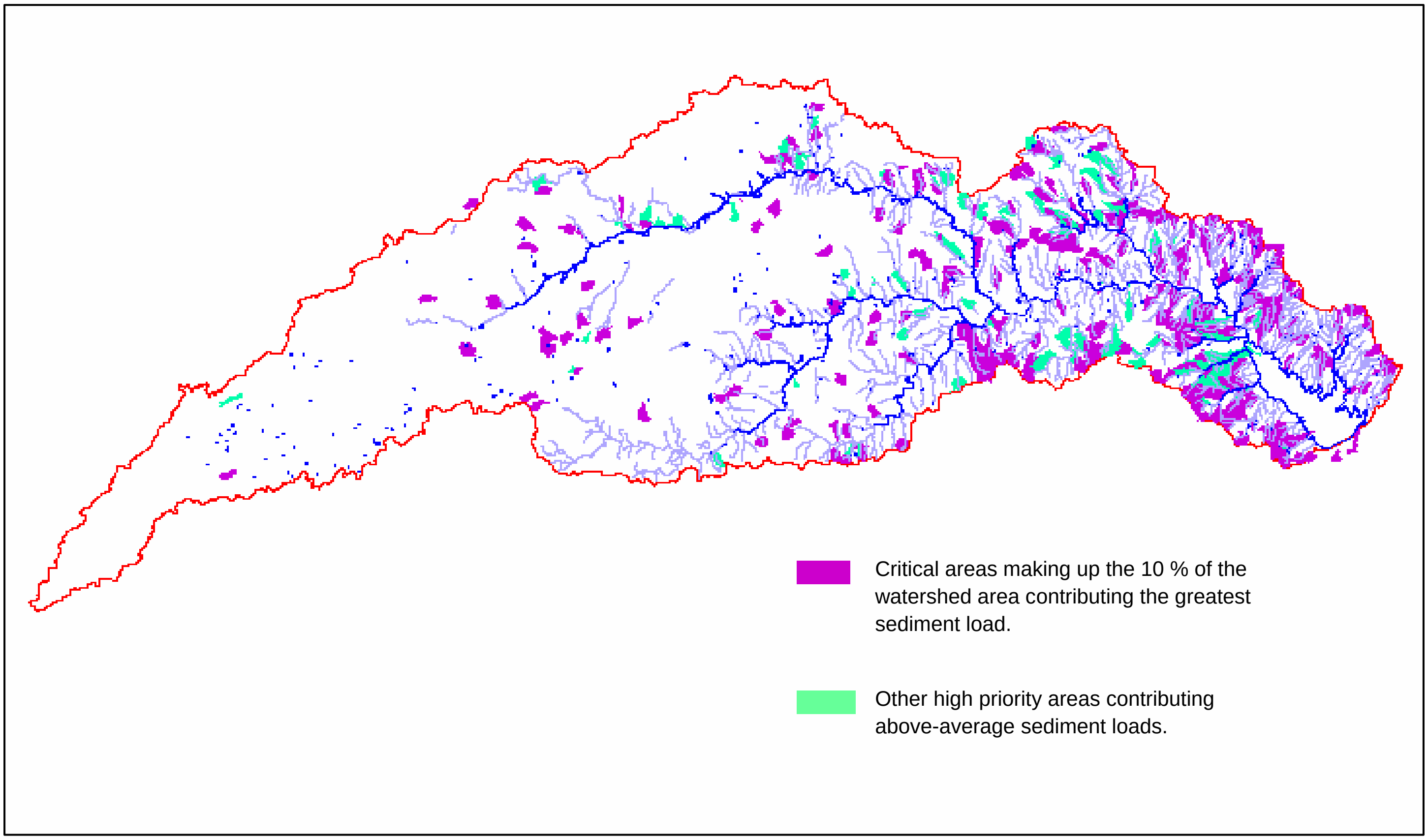

Figure 6. — Sediment load contribution (model-generated) with respect to watershed outlet in Cheney Lake Watershed

according to the enhanced AnnAGNPS model.

Conclusions — Implications and Application in the Watershed

The finding that 10 percent of the watershed is contributing 76 percent of the sediment load to Cheney Reservoir could be used to make significant changes in the implementation of conservation measures. A significant portion of the sediment source is ephemeral gullies in tilled fields. If all ephemeral gullies within the watershed are treated with conservation practices specifically designed to address this type of erosion, the sediment load to the reservoir could be reduced by 35 percent according to the simulation model.

The broader implication for this watershed and for other watersheds with similar conditions is that voluntary implementation of conservation practices to address specific sources of sediment in specific locations within the watershed will result in more rapid water quality improvement than random voluntary implementation of conservation practices. When funding and technical assistance are limited the ability to identify and rank the pollutant sources will be critical in focusing assistance in areas that will provide the greatest improvements.

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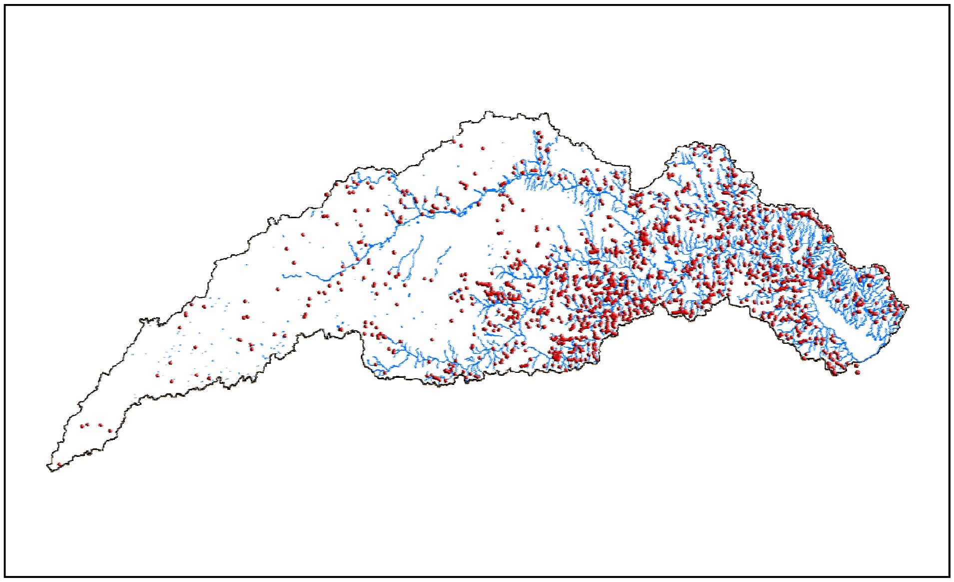

Figure 7. — Model-generated points where ephemeral gully erosion can originate in Cheney Lake Watershed

The Conservation Effects Assessment Project — Building the Science Base

The Conservation Effects Assessment Project (CEAP) is a multi-agency effort to scientifically quantify the environmental benefits of conservation practices used by private landowners participating in U.S. Department of Agriculture (USDA) conservation programs. Project findings will help to guide USDA conservation policy and program development and help farmers and ranchers make informed conservation choices.

Critical to building the CEAP science base are the in-depth studies that address specific resource concerns in representative watersheds nationwide. The research from these watershed studies enhances our understanding of conservation practice effects at the local landscape level and will provide guidance on what practices are the most effective in controlled non-point source pollution, and where in the watershed these practices should be implemented to cost effectively address environmental impairment.

The Cheney Lake Watershed assessment study is one of eight Special Emphasis Watershed studies managed by the Natural Resources Conservation Service.

Other CEAP watershed studies are being conducted by the Agricultural Research Service and the Cooperative State Research, Education and Extension Service.

For more information:
www.nrcs.usda.gov/technical/NRI/ceap/